CLAIMS

What is claimed is:

1. A method for forming a diffractive lens, comprising:

forming a stack comprising at least two phase shifting layers separated by an etch stop layer above a first surface of a transparent substrate, the transparent substrate being transmissive to a light wavelength selected from infrared to ultraviolet; and

patterning the stack to form layers of a diffractive optical element.

2. The method of claim 1, wherein the transparent substrate comprises a material selected from the group consisting of quartz, Pyrex, and sapphire.

3. The method of claim 1, wherein said forming a stack comprises:

(1) depositing a first phase shifting layer comprising a material selected from the group consisting of amorphous silicon and silicon nitride;

(2) growing an etch stop layer comprising silicon dioxide on the first phase shifting layer; and

(3) depositing a second phase shifting layer comprising the material on the etch stop layer.

4. The method of claim 1, further comprising forming an opaque coating on a second surface of the substrate.

5. The method of claim 4, wherein the opaque coating comprises amorphous silicon.

6. The method of claim 1, further comprising, prior to said forming a stack:

forming an antireflective coating on the first surface of the transparent substrate, wherein the stack is formed on the antireflective coating.

7. The method of claim 1, further comprising, subsequent to said patterning the stack:

forming an antireflective coating over the diffractive optical element.

8. The method of claim 1, further comprising bonding a bonding ring to the first surface of the transparent substrate around the diffractive optical element.

9. The method of claim 8, wherein said bonding comprises forming a bond between the bonding ring and the transparent substrate selected from the group consisting of an anodic bond, an adhesive bond, a hydrofluoric acid bond, and a glass frit bond.

10. The method of claim 8, further comprising bonding a submount to the bonding ring to form a package.

11. The method of claim 1, further comprising bonding a submount to the first surface of the transparent substrate with silicone.

12. The method of claim 1, wherein the transparent substrate comprises a device layer of a silicon-on-insulator (SOI) substrate, the SOI substrate further comprising an insulator layer below the device layer and a handle layer below the insulator layer, the method further comprising:

etching the handle layer to the insulator layer to remove a portion of the handle layer opposite the diffractive optical element, wherein the remaining portion of the handle layer forms a bonding ring.

13. The method of claim 12, further comprising:

etching the insulator layer to remove a portion of the insulator layer opposite the diffractive optical element.

14. The method of claim 13, further comprising:

forming an antireflective coating on a second surface of the device layer opposite the diffractive optical element.

15. The method of claim 12, further comprising:

forming a bonding pad on the bonding ring.

16. The method of claim 12, further comprising:

forming a planarization layer over the diffractive optical element; and

planarizing the planarization layer.

17. The method of claim 16, further comprising:

forming an antireflective layer on the planarization layer.

18. A diffractive lens, comprising:

a transparent substrate being transmissive to a light wavelength selected from infrared to ultraviolet; and

a diffractive optical element above a first surface of the transparent substrate, the diffractive optical element comprising at least two phase shifting layers separated by an etch stop layer.

19. The lens of claim 18, wherein the transparent substrate comprises a material selected from the group consisting of quartz, Pyrex, and sapphire.

20. The lens of claim 18, further comprising an opaque coating on a second surface of the substrate.

21. The lens of claim 20, wherein the opaque coating comprises amorphous silicon.

22. The lens of claim 18, further comprising:

an antireflective coating between the first surface of the transparent substrate and the diffractive optical element.

23. The lens of claim 18, further comprising:

an antireflective coating over the diffractive optical element.

24. The lens of claim 18, further comprising:

a bonding ring bonded to the first surface of the transparent substrate around the diffractive optical element.

25. The lens of claim 24, wherein the bonding ring is bonded to the transparent substrate by a bond selected from the group consisting of an anodic bond, an adhesive bond, a hydrofluoric acid bond, and a glass frit bond.

26. The lens of claim 18, further comprising:

a submount bonded to the bonding ring to form a package.

27. The lens of claim 18, further comprising:

a submount bonded to the first surface of the transparent substrate with silicone.

28. The lens of claim 18, wherein the transparent substrate comprises a device layer of a silicon-on-insulator (SOI) substrate, the SOI substrate further comprising an insulator layer

below the device layer and a handle layer below the insulator layer, the handle layer being etched so the remaining portion of the handle layer forms a bonding ring.

29. The lens of claim 28, further comprising:

an antireflective coating on a second surface of the device layer opposite the diffractive optical element.

30. The lens of claim 28, further comprising:

a bonding pad on the bonding ring.

31. The lens of claim 28, further comprising:

a planarization layer over the diffractive optical element.

32. The lens of claim 28, further comprising:

an antireflective layer over the planarization layer.

33. A method for forming a diffractive lens, comprising:

forming an etch stop layer on a first surface of a silicon substrate;

forming a diffractive optical element above the etch stop layer;

forming a planarization layer over the diffractive optical element;

planarizing the planarization layer;

bonding a transparent substrate to the planarization layer, the transparent substrate being transmissive to a light wavelength selected from infrared to ultraviolet; and

etching a second surface of the silicon substrate to the etch stop layer to remove at least a portion of the silicon substrate opposite the diffractive optical element.

34. The method of claim 33, wherein the transparent substrate comprises a material selected from the group consisting of quartz, Pyrex, and sapphire.

35. The method of claim 33, wherein said forming a diffractive optical element comprises:

forming a stack comprising at least two phase shifting layers separated by another etch stop layer above; and

patterning the stack to form layers of the diffractive optical element.

36. The method of claim 33, wherein said bonding a transparent substrate to the planarization layer comprises:

forming a bonding layer on the planarization layer; and

bonding the transparent substrate on the bonding layer by an anodic bond.

37. The method of claim 33, further comprising, prior to said forming a diffractive optical element:

forming an antireflective layer on the etch stop layer, wherein the diffractive optical element is formed on the antireflective layer.

38. The method of claim 37, further comprising:

etching the etch stop layer to remove a portion of the etch stop layer opposite the diffractive optical element.

39. The method of claim 33, wherein the remaining portion of the silicon substrate forms a bonding ring.

40. The method of claim 39, further comprising:

forming a bonding pad on the bonding ring.

41. The method of claim 39, further comprising:

bonding a submount to the bonding ring to form a package.

42. The method of claim 33, wherein said etching a second surface of the silicon substrate further comprises removing all of the silicon substrate.

43. A diffractive lens, comprising:

a transparent substrate being transmissive to a light wavelength selected from infrared to ultraviolet;

a planarization layer below the transparent substrate;

a diffractive optical element below the planarization layer; and

an etch stop layer below the diffractive optical element.

44. The diffractive lens of claim 43, wherein the transparent substrate comprises a material selected from the group consisting of quartz, Pyrex, and sapphire.

45. The diffractive lens of claim 43, wherein the diffractive optical element comprises at least two phase shifting layers separated by another etch stop layer.

46. The diffractive lens of claim 43, further comprising:

a bonding layer between the transparent substrate and the planarization layer.

47. The diffractive lens of claim 43, further comprising:

an antireflective layer between the etch stop layer and the diffractive optical element.

48. The diffractive lens of claim 43, further comprising:

a bonding ring below the etch stop layer.

49. The diffractive lens of claim 48, further comprising:

a bonding pad on the bonding ring.

50. The diffractive lens of claim 48, further comprising:

a submount bonded to the bonding ring to form a package.

51. A method for forming a diffractive lens, comprising:

forming a mold for a diffractive optical element on a first surface of a silicon substrate;

forming a lens layer above the mold, wherein the lens layer conforms to the mold to form the diffractive optical element, the lens layer being transmissive to a light wavelength selected from infrared to ultraviolet;

planarizing the lens layer;

bonding a transparent substrate to the lens layer; and

etching a second surface of the silicon substrate opposite of the diffractive optical element, wherein the remaining portion of the silicon substrate forms a bonding ring.

52. The method of claim 51, further comprising, prior to said forming a lens layer above the mold:

forming an etch stop layer on the mold; and

wherein the lens layer is formed on the etch stop layer and said etching a second surface of the silicon substrate comprises etching the silicon substrate to the etch stop layer.

53. The method of claim 51, wherein the lens layer comprises a material selected from the group consisting of silicon nitride and silicon dioxide.

54. The method of claim 51, wherein the transparent substrate comprises a material selected from the group consisting of quartz, Pyrex, and sapphire.

55. The method of claim 51, wherein said forming a mold comprises:

forming a stack comprising at least two lens layers separated by an etch stop layer; and

patterning the stack to form layers of the diffractive optical element.

56. The method of claim 51, further comprising:

forming a bonding pad on the bonding ring.

57. The method of claim 51, further comprising bonding a submount to the bonding ring to form a package.

58. A diffractive lens, comprising:

a transparent substrate being transmissive to a light wavelength selected from infrared to ultraviolet;

a diffractive optical element below the transparent substrate; and

a bonding ring below the diffractive optical element.

59. The diffractive lens of claim 58, further comprising:

an etch stop layer between the diffractive optical element and the bond ring.

60. The diffractive lens of claim 58, wherein the diffractive optical element comprises a material selected from the group consisting of silicon nitride and silicon dioxide.

61. The diffractive lens of claim 58, wherein the transparent substrate comprises a material selected from the group consisting of quartz, Pyrex, and sapphire.

62. The diffractive lens of claim 58, further comprising:

a bonding pad on the bonding ring.

63. The diffractive lens of claim 58, further comprising:

a submount bonded to the bonding ring to form a package.